Space Weather Technical Forecast

Issued on Tuesday, 28 December 2021 at 00:37 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Geomagnetic storms, peaking Thursday 29 December. Chance of R1 radio blackouts and Active electron fluence throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional C-class X-ray flares observed at GOES 16 in the period. The largest of these flares reached C2.2 at 27/2336UTC, and emanated from AR2918 in the northwestern quadrant.

There are currently up to six active regions on the solar disc at present, including two as yet unnumbered in the northwestern quadrant, currently both showing as tenuous bipolar Bxo/Beta groups, but with the northwesternmost showing a late growth trend. The disc was otherwise little changed on the preceding 24 hours, with 2919 remaining a unipolar Hrx/Alpha in the southeast, while earlier growth in 2920 in the southwest stalled, with the group retaining Cri/Beta complexity. The disc was otherwise dominated in terms of complexity and sunspot area by a pair of large sunspot regions: firstly AR2916 in the southeastern quadrant, which showed slight proliferation but retained a similar size and stature, with Ehi/Beta complexity. This left AR2918 in the northwest as a Eai/Beta, with new leading sunspots developing later in the 24 hours, having briefly faded to render the group a Zurich 'Dai' for a period.

No Coronal Mass Ejections (CMEs) were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, was symptomatic of a Co-rotating Interacting Region (CIR) seguing into a coronal hole, probably that from CH37/+, an extension of the northern crown.

The solar wind speed rose from background levels near 310km/s to peak at around 475km/s, with the bulk of the increase occurring on onset of the coronal hole proper, shortly before 27/1500UTC. The solar wind density also showed a marked increase, peaking at around 35ppcc around the middle of the UTC day, falling to mid-single figures early and late. The IMF also displayed the middle of the day peak, reaching 15nT before moderating into the UTC evening, with the north-south component varying between +/-10nT. Finally, the phi angle was rather variable prior to the coronal hole's influence, eventually becoming decidedly positive (away from the sun) after 27/1500UTC.

The net result of the above solar wind measures was provisionally mainly Quiet, but with a peak of Kp '4-' in the 12-15UTC interval, while the IMF and density were highest.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels.

The high energy electron flux (greater than 2 MeV) ranged between Moderate and High flux initially, peaking at 3210pfu at both 27/1230 and 27/1325UTC, before falling to Normal

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Background with the onset of increased geomagnetic activity later in the UTC day. The fluence initially rose to threaten the 1e8 Active threshold, before falling away later in the period. The 24-hour observed fluence at 28/0000UTC was 5.08e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is forecast throughout the period, but with a daily chance of increasing to Moderate, with isolated M-class flares, most likely from AR2916 and AR2918. No significant regions leave or arrive on the disc in the period.

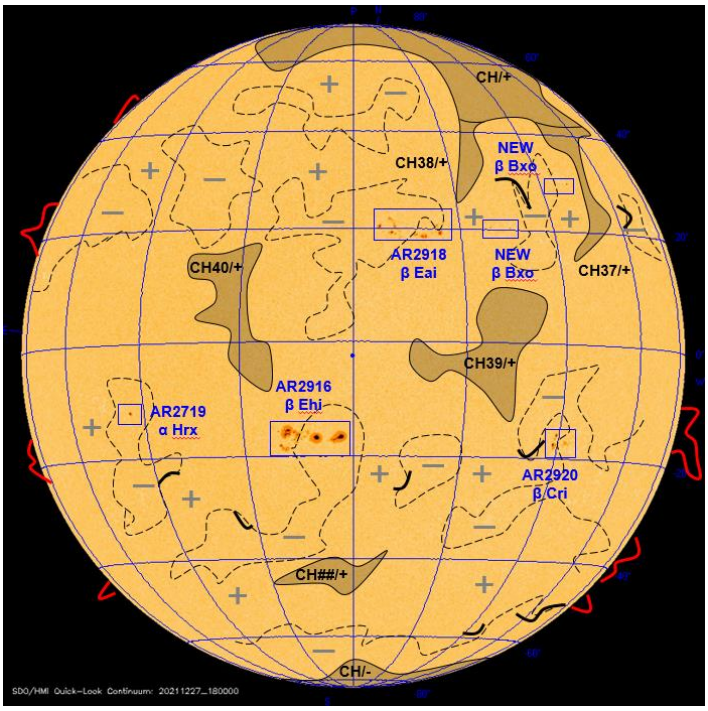
Solar Wind / Geomagnetic Activity: While most likely missing Earth, there is a Slight Chance of G1 should a CME from the 26/2012UTC filament eruption glance Earth on day 3 (Friday 30 December).

The chances of G1 should peak (30%) for the period as a whole on onset of CH39's high speed stream, perhaps most likely at the very end of day one or day two (Thursday 29 December). If the aforementioned CME does not feature, a lull should then ensue through day three, before possible influence from CH40 to end the four days, giving a further Slight Chance of G1.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, albeit with a daily Slight Chance of S1 should there be any significant flare activity.

High energy electron flux (greater than 2MeV) levels are relatively uncertain, but will most likely track near the Active threshold with peaks in risk on days one and three, in antiphase with the most likely onset times of coronal holes.

Figure 1. Solar Analysis Valid 27/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is a small chance on day three, Friday 30 December. of peripheral effects from a glancing blow from a filament eruption which occurred 26/2012UTC. This is currently forecast to most likely miss Earth, but again confidence is low given some MOSWOC Enlil ensemble members have glancing blows of Earth No other CMEs feature.

The coronal hole forecast for the same period is of lower confidence than is typical, both for the lack of similarity of the current disc with last pass, but also the apparent dissimilarity of current conditions with those seen at STEREO A 2.7 days upwind of Earth. Specifically, the current coronal hole enhancement, perhaps from CH37/+, is not especially obvious in MAG and PLASTIC data for the relevant period, with a more obvious spike due late day one or perhaps early day two (Thursday 29 December), with this thought to emanate from CH39/+. This should provide the peak risk of geomagnetic storm intervals in the period, waning to end the working week but with a token 5% risk maintained should CME effects materialise. The four days are then rounded out by a slightly more assured high speed stream from a persistent coronal hole, numbered CH40/+.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0418UTC	N/A	Filament eruption	SW quadrant	507km/s	Probable miss, minority of ensemble members suggest later half of Friday 30 December	Small chance of glancing blow.

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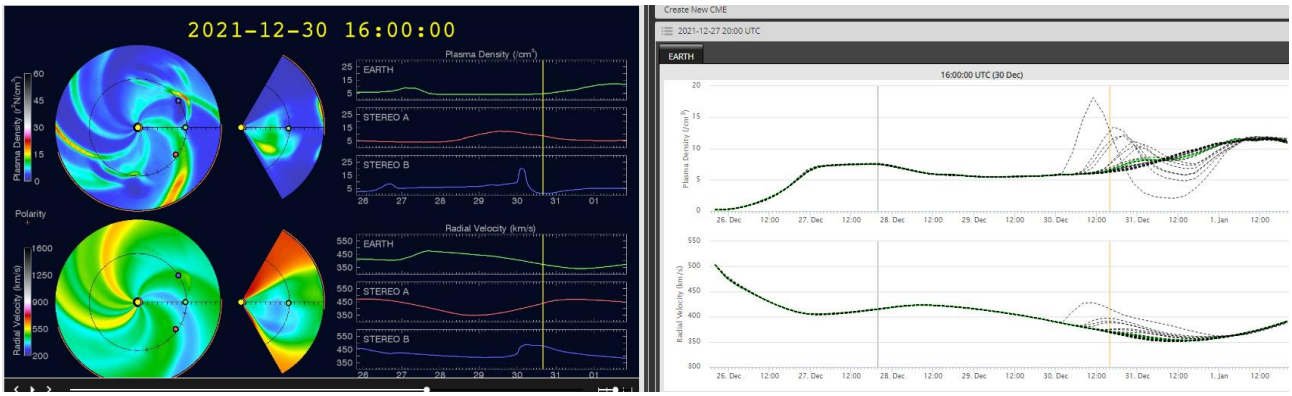
Figure 2: Latest MOSWOC Enlil run with ensemble, showing a small minority of members suggest a glacing blow is possible from a filament eruption CME that left the sun 26/2012UTC. The most likely scenario is considered to be that this feature misses Earth, with a 5% chance of G1 suggested.



Radio Blackouts - X-Ray Flares:

Solar Activity has been Low, with several small C-flares again seen through the past 24 hours. Background X-ray flux recorded at GOES 16 continued to show an overall slight decline. The current Earth-facing disc is dominated areally by 2916 and 2918, although neither of these regions has delivered the full scope of their class, being Ehc/Beta and Eai/Beta respectively.

In terms of overall trends, no major returning regions are forecast over the eastern limb in the coming four-day period, while none of the more signficant front-sided regions leave the disc, leading to a flat X-ray flare tendency. Solar activity is Expected to be Low, with further C-class flares. There is a daily Chance of activity increasing to moderate levels, with isolated M-class flares. These are most likely to come from 2916 and 2918.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels and will most likely persist as such. There is a Slight Chance of S1 from any notable flares on the disc, perhaps most likely from AR2916 or AR2918 as they rotate into the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The diurnal oscillation in high energy (greater than 2MeV) electron flux, as observed by GOES-16 again showed an increase through the first half of the past UTC day, only to be attenuated by the arrival of a coronal hole high speed stream, perhaps that from CH37/+. Because the solar wind environment that Earth is encountering in this four-day period bears little resemblance to persistence, confidence is notably low for the period as a whole, with REFM's recent forecast trends markedly lower than observations and also proving very volatile.

There is a Chance of Active fluence being realised once geomagnetic activity eases from the current high speed stream, probably only to be interrupted once again after midweek by a further high speed stream from CH39/+. The onset of CH40/+ is of higher confidence, for bearing greater similarity to its past incarnation. This may mean that arrival is most likely on day four, Saturday 31 December, again potentially denting electron fluence levels for a time.

The forecast for fluence is therefore of low confidence throughout, but probably showing slightly higher chances of exceedence in the wake of the current coronal hole and CH39/+.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	40	30	40	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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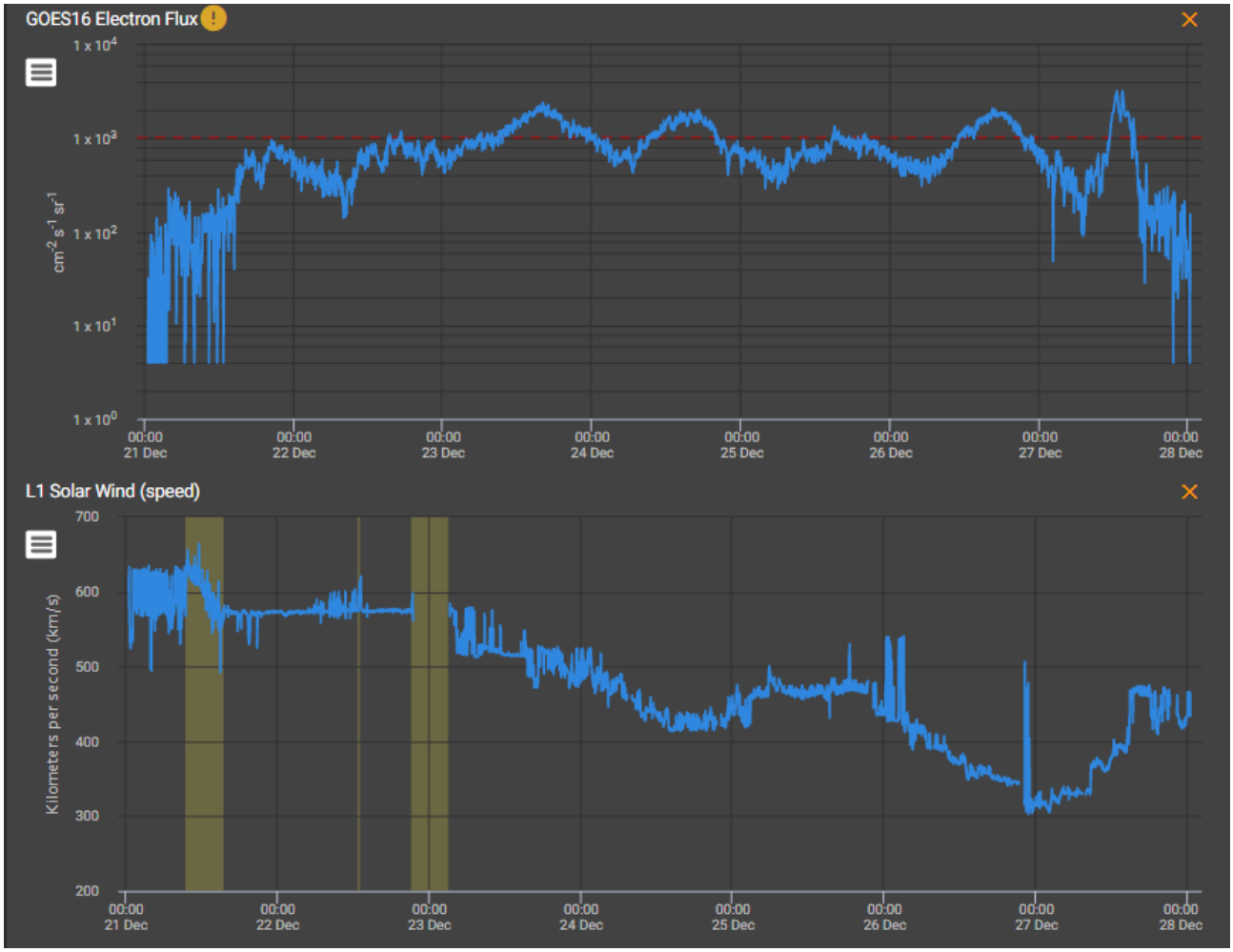
Figure 3: The past week in high energy electrons at GOES 16, with L1 solar wind speed also shown. Levels had been increasing before the onset of the latest high speed stream, with an uncertain degree of recovery now expected before CH39 and CH40 arrive in succession in the four-day period.



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